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INTENDED R&D KNOWLEDGE SPILLOVER – INNOVATION STRATEGY FOR INNOVATION LEADERSHIP

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Abstract

Given the increasing focus on intellectual capital as the most valuable assets of many knowledge intensive companies, we might assume that the knowledge constituting valuable intellectual capital should ideally be kept secret for entities external to the company. This protective logic may, however, inhibit companies striving for innovation leadership. In our enquiry into R&D knowledge spillover effects on innovation, we develop case studies from Porsche and Tetra Pak. The resulting theoretical framework, built on selected networking and knowledge creation theories, is illustrated through the two case studies and useful for further analysis of positive R&D knowledge spillover effects.

By proactively facilitating knowledge sharing with relevant parts of the surrounding environment, the company enables itself to feed knowledge into its surrounding environment - thereby developing the innovation potential of the environment for exploration purposes, and the opportunities to identify and to feed knowledge back to the company for exploitation purposes, from the same environment.

Keywords: positive knowledge spillover, networked innovation, knowledge creation.

1. INTRODUCTION

Knowledge spillover is generally mentioned in the literature as something potentially negative and as something, which for instance, MNCs investing in knowledge intensive activities in emerging economies have to consider. Given the increasing focus on intellectual capital as the most valuable assets of many knowledge intensive companies, it may be logical to assume that the knowledge constituting valuable intellectual capital should ideally be kept secret for entities external to the company. This protective logic may, however, inhibit companies striving for innovation leadership. Negative R&D knowledge spillover can be defined as the use, by competitors, of spillover knowledge, in ways which are directly or indirectly harming the company. Such harming ways could be the unwelcomed establishment of competing companies based on spillover knowledge. Another example could be simple disclosure of information which could otherwise have been turned into valuable and strategically important IPR. An

underlying assumption of this article is that innovation is to a high extent driven by individuals. Allen (1977) and Allen and Henn (2006) explain why the R&D output per R&D employee generally decreases when the number of R&D employees increases in an R&D department. One interpretation of these results would suggest that it is equally if not more important to have access to the right external R&D brains than having internal ownership of many R&D brains, since the number of R&D employees it is possible to manage, still maintaining relative effectiveness, may be limited. This article explores how knowledge spillover can be used to identify the right R&D brains to get access to. Our enquiry into R&D knowledge spillover (knowledge spillover) effects on innovation is based on empirical material from Porsche and Tetra Pak and it speaks to the following themes of the 10th CINet conference:

- Innovation in emerging economies
- Open innovation
- New product development & continuous innovation

2. THEORETICAL FRAMEWORK

2.1 INTRODUCING A NETWORK PERSPECTIVE TO ANALYZE INNOVATION

Several authors (Aldrich and Whetten, 1981; Andersson, 1998; Bartlett and Ghoshal, 1989; Easton, 1992; Håkansson and Ford, 2002; Håkansson and Henders, 1992; Håkansson and Laage-Hellman, 1984; Laage-Hellman, 1997; Jansson et al., 1990; Harryson, 2002; Johansson and Elg, 2002) have adopted a network perspective in which relationships and linkage patterns constitute the core element of analysis. Some general elements of a network perspective are:

- Networks typically emerge because no organization is self-sufficient, but rather dependent on extra-organizational resources for its sustained competitiveness;
- A network perspective aims at understanding the totality of relationships and how they jointly accomplish the result;
- Networks are often divided into different levels so as to better concentrate the level of analysis to a specific phenomenon where the main-activities happen at that specific level of the network.

We attempt to build theory having networking theory as a starting point. Our paper uses theories on networking (Ahuja, 2000; Uzzi and Dunlap, 2005), and knowledge creation

We certainly know that ‘no business is an island’ (Håkansson and Snehota, 1989; Håkansson and Johanson, 2001) in today’s business context. Sophisticated networks support creation and application of knowledge all the way through from key-suppliers to the factory complex where social interaction between individuals, groups and organizations is fundamental to the corporate knowledge creation process.

Håkansson (1987; 1989; 1990) considers how companies handle their technological development in relation to external clients and organizations, particularly in terms of collaborative projects, claiming that the question is not how the company manages its technological development per se, but ‘*how it manages to relate its technological development to what is happening inside and between other organizations*’ (Håkansson, 1990, 371). In line with the essence of holism, the right combination of technologies

and skills often yields a whole that is greater than the sum of its parts. Accordingly, it is essential to know where these parts are and, more essential still, to know who can best contribute to their transfer and transformation, and integrate the parts into a greater whole (Harryson, 1998; Uzzi and Dunlap, 2005).

While the transaction cost perspective takes transactions as given, instead of considering their creation, and stresses the efficiency benefits from reducing the governance cost of a transaction, a network perspective allows consideration of the strategic benefits from optimizing not just a single relationship but the firm's entire network of relationships, or know-who (Dyer and Nobeoka, 2000; Harryson, 2000; 2006). Indeed, a firm's alliance formation capabilities and the resulting networks can be thought of as creating inimitable and non-substitutable value as inimitable resources by themselves, and as a means to access further inimitable resources and capabilities (Gulati et al., 2000; Powell et al., 1996; Van Wijk et al., 2003).

2.1.1 THE SYNERGY BETWEEN INTERNAL AND EXTERNAL NETWORKING

Companies that move from know-how to know-who make extraordinarily effectiveⁱ and efficientⁱⁱ use of external networking to acquire both tacit and explicit knowledge with and from extracorporate centers of excellence. These external knowledge links free up employees in the company to participate in sophisticated processes of internal networking with three critical objectives:

1. To make corporate synergies in R&D possible through more effective transfer, transformation and application of knowledge across divisions and business units.
2. To increase R&D efficiency by ensuring that all R&D activities are attuned to market needs and marketing and sales (M&S) activities.
3. To enhance R&D effectiveness by securing an earlier and more intensive knowledge transfer between R&D and design and manufacturing (D&M).

A failure to exploit synergies, attune R&D to market needs and turn the results into manufacturable products is more often than not a fundamental innovation barrier of companies that rely too strongly on internal technology development. This is why this book proposes more know-who-based approaches to entrepreneurship so as to capture unique synergies between internal and external networking to circumvent the barriers against innovation and even transform the worst ones into the best enablers of innovation.

2.1.2 THE KNOW-WHO BASED APPROACH TO INNOVATION

The know-who based approach to innovation aims at identifying the essential parts that contribute to the corporate knowledge & innovation (K&I) management process. In this context, three interrelated levels with different foci can be outlined:

1. Extracorporate *creativity networks* as primary sources of new knowledge and emerging technologies.
2. Intracorporate *process networks* for more effective transformation of invention into innovation – across the key functions R&D, design & manufacturing (D&M), marketing & sales (M&S) and product management.

3. *Project networks* interlinking and combining the different (opposing) characteristics and benefits of the aforementioned creativity networks and process networks.

As suggested by Figure 1, project networks are human networks that drive growth through innovation by building know-who links to span the organizational chasm between creativity the empirical section, creativity networks tend to be small by size and are usually self-managed in an organic fashion. By contrast, process networks are large in size and, therefore, typically managed by hierarchy in a mechanistic structure. It seems as if only human networks can bridge the chasm between creativity- and process networks.

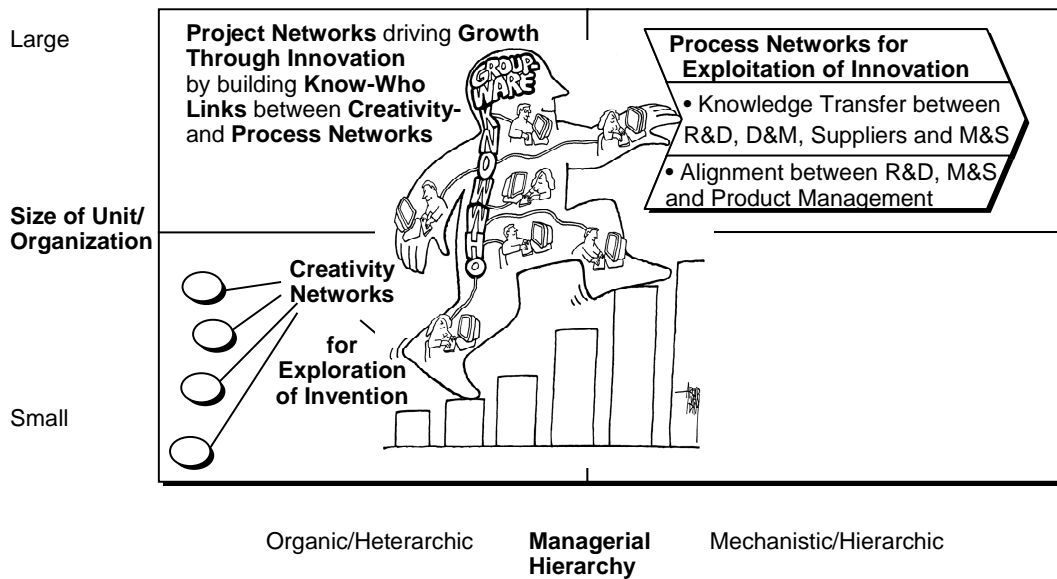


Figure 1 Driving GTI by Transforming Knowledge Creation into Business Implementation Through Human Networks

2.1.3 THE PROCESS NETWORK AS HIERARCHY AND THE CREATIVITY NETWORK AS ARM'S LENGTH

Connectivity, or, the degree to which the organizations or persons are linked to each other, is a major aspect of the network structure (Jansson, 2006). We can make a distinction between arm's length (external) and hierarchical (internal) networks. Arms-length relations are formed to facilitate concerted action on the part of autonomous organizations in situations where there is no formal authority to impose coordination, which corresponds to the structure of creativity networks. A network having an authority directly present within the network to control is defined as a hierarchical network, which corresponds to the process network in the theoretical framework.

2.1.4 THE PROJECT NETWORK AS AN EXTENDED ACTION NETWORK

The project network in Figure 1 is established to transform knowledge from the arm's length creativity network into a product/service. When the task of this network is

completed, the project network is typically dissolved, and the units remaining in the organization network are awaiting formation of future project networks. Three project networks explored by (Harryson, 1998; 2002; 2006) demonstrated the same phenomenon: As they progressed from exploration to exploitation, they not only grew in size, but also went through a change in project leadership from a less senior person with informal management style to more senior and organizationally strongly positioned person. This is a reflection of the need to move from an open organic network to a more closed and hierarchic structure to manage the transition from exploration to exploitation. It is the management of this transition that can secure a conversion of knowledge creation into business implementation for implementation of innovation.

The transition will be illustrated in the mini-case where Spiderman establishes a project network to develop a revolutionary ceramic brake system. This started as a rather organic team of externally networked employees, who identified and integrated complementary skills and technologies from a broad variety of creativity networks, such as universities, and also from a few process networks, such as specialized suppliers in Europe and in the USA. As the project network shifted its focus from exploration to exploitation, a selection of the previously external experts were internalized into a Porsche unit dedicated to commercializing the results. Through this integration, the project network partly transformed from an open arms-length network into a more closed and hierarchically controlled process network.

2.1.5 DRAWING A LINK TO THE HYPERTEXT ORGANIZATION

As an alternative attempt to clarify the distinction between action networks and hierarchical networks, Nonaka's *hypertext organization* combines the stability of a hierarchical bureaucratic organization with the dynamism of the flat, cross-functional task-force organization through coordination of time, space and resources (Nonaka, 1994, 33):

The hypertext organization is an organizational structure that enables orchestration of different rhythms or 'natural frequency' generated by various project teams and the hierarchical organization. It coordinates the allocation of time, space and resource within the organization so as to compose an 'organizational' rhythm that makes organizational knowledge creation more effective and efficient.

There are three layers in the hypertext organization. The lowest layer, the *knowledge base*, constitutes a corporate university of tacit and explicit knowledge, or a 'clearinghouse for the new knowledge generated' (Nonaka and Takeuchi, 1995, 170). There is no corresponding term or function described in conventional networking theories, but we see strong similarities with so-called *knowledge networks*. The second layer, the *business system*, is the formal hierarchical organization in which the routine operations are carried out. This corresponds to the hierarchical networks in classic networking theories and the process networks in Figure 1. Finally, Nonaka's loosely linked *self-organizing project teams*, including the area in which they create knowledge, constitute the top layer corresponding to the project network in Figure 1.

At the very same time as Nonaka introduced his hypertext organization, (Hedlund, 1994; 1995, 20) proposed a concept of a three-dimensional organization structure with striking similarities: 'a *positional* one which is likely to resemble a traditional hierarchy, one for

knowledge and one for *action*, where the use of temporary projects and teams figure prominently’.

Organizational knowledge creation is a process of dynamic knowledge and information cycles that traverse all three layers. Members of project teams are selected from diverse functions and departments across the business-system layer to engage in knowledge-creating activities. Once the task is completed, the team members move down to the knowledge-base layer to make an inventory of the knowledge created. When this is completed, the members move up again, back to their original business-system layer to perform routine activities until new projects are created. This is a continuous process and ‘*the ability to switch swiftly and flexibly between the three layers in the hypertext organization is critical to its success*’ (Nonaka, 1994, 33). Similarly, the success factor in Porsche’s commercialization of ceramic brakes was Spiderman’s rapid access to experts (*die kurze Wege der Experten*) within and beyond the company (Harryson and Lorange, 2005). The knowledge created in the teams is different from that accumulated in the business-system, and both types of knowledge are mixed into the knowledge base of the hypertext organization. Porsche acquired a unique ceramic technology for revolutionary brake systems. Once acquired, the related knowledge and technology were stored and diffused to another division that applied them to a high performance clutch system.

(Nonaka and Takeuchi, 1995, 171) do not describe how to develop a capability to acquire and integrate extracorporate knowledge. In fact, neither conventional networking theory nor Nonaka or Hedlund propose any equivalent of the creativity network in Figure 1. Moreover, they do not describe the participation of external experts in their respective action networks. As this is an essential component in know-who based entrepreneurship, it will be amply illustrated in the case studies. Another dimension that seems to be lacking in most theories and concepts is the synergetic relationship between external and internal networking that drives knowledge creation and innovation in know-who based entrepreneurship. The roots of this synergy can partly be explained with those networking theories that distinguish between the nature and characteristics of open and close networks, based partly on weak and strong ties – outlined below.

2.1.6 INTRODUCING OPEN AND CLOSED NETWORKS

Along the connectivity dimension of the social network, we can distinguish between open and closed networks. Having no social capital on which to rely, the open network is mainly about resource exchange of information, while the closed network focuses on social exchange, trust and shared norms (Walker et al., 1997). An example of an open network is one in which firms have direct social contacts with all their partners, but these partners do not have any direct contacts with each other. A high number of such non-connected parties, or structural holes, means that the network consists of few redundant contacts and is information rich, since people on either side of the hole have access to different flows of information (Burt, 1992; 1993). This implies that the structure of an open network is suitable when the purpose of the network is knowledge creation by maximizing the number of contacts gathering, processing and screening new sources of information. This kind of creativity network then stresses the indirect linkage, has mainly weak relationships and is loosely coupled.

The opposite is the tightly coupled closed network, where all partners have direct and strong ties with each other. This network is centered on social capital, which is built through trust and shared norms and behavior (Coleman, 1988). Embeddedness in dense networks supports effective knowledge transfer and interfirm cooperation (Ahuja, 2000; Granovetter, 1985; Walker et al., 1997). This corresponds to the ideal characteristics of a process network in Figure 1.4.

2.1.7 PROPOSING AN OPTIMAL NETWORK STRUCTURE

Ahuja (Ahuja, 2000) lights the contradiction between open and closed networks and proposes that the larger the number of structural holes spanned by a firm, the greater its innovation output. There seems to be a trade-off between a large loosely coupled network that maximizes information benefits and a smaller tightly coupled network promoting trust building and more reliable information. This contraction is studied in the context of project teams by Soda et al. (2004) who argue that the best performing teams are those with strong ties among the project members based on past joint-experience, but with a multitude of current weak ties to complementary, non-redundant resources. By mainly recruiting researchers who have already worked as academic collaboration researchers, Porsche illustrates the suggested model of Soda et al. (2004) in getting project teams with high past closure (strong ties within the team based on prior collaboration) and high current structural holes (multiple weak ties to nonredundant resources at universities held by the new recruits). Chapter 7 offers more empirical support to this theoretical argument.

If we apply the findings of Soda et al. (2004) to our general framework in Figure 1.4, the project networks will typically optimize performance by having core team members who share strong past experience while also having many weak ties to complementary resources that can take the form of creativity networks. Again, this corresponds perfectly to the project network of Spiderman, who had strong ties to all his internal team members – all of whom had many weak ties to complementary knowledge both within and outside of Porsche. However, some of the nonredundant external ties were strong – not weak. One example is the link to Mr. Grandissimo who provided the critical brakepads. We may need further levels of distinction that goes beyond this initial argument of strong and weak ties.

2.1.8 EXPLORING THE STRONG IMPORTANCE OF WEAK TIES

Granovetter is the pioneer in highlighting and exemplifying the importance of weak ties in linking otherwise unconnected networks. He argues that individuals with few weak ties have difficulties to be up-to-date with information from distant parts of the social system, and that '*social systems lacking in weak ties will be fragmented and incoherent*' (Granovetter, 1973, 106). In the context of innovation he argues that new ideas more often emanate through weak ties from the margins of a specific network rather than through strong ties from its core or its nucleus. Accordingly, the relative strength of weak ties can transform marginal idea creating networks into a new nucleus of innovation. This argument poses new challenges to the science of innovation management: if the idea creation process is centered within and around marginal networks and their relatively unstructured weak ties, it becomes difficult to manage the

main source of innovation and hence also difficult to control the innovation process as a whole – at least if attempted to do it all within one and the same company.

As it is argued that weak ties can be developed and leveraged quite easily (Håkansson et al., 1999), the good news is that creativity and new ideas can be acquired with no trouble. On the other hand, the weak tie argument suggests that it is very challenging to influence the outcome of such creativity, as it is hard to actually control activities emerging through weak ties (cf., Tidd et al., 2001). Accordingly, all case studies will include the dimension of managing partly or entirely external creativity networks. In addition, Chapter 7 will be devoted to illustrate and explore how companies can steer and control external exploratory research – performed in collaboration with universities.

In many cases, innovation requires management of both weak and strong ties cutting across both peripheral and core networks with a strong focus on developing and managing relationships for transfer and transformation of information into innovation. Therefore, it seems critical to analyze and better understand the nature of the ties in the three types of networks outlined in Figure 1.4.

2.1.9 WEAK TIES FOR SIMPLICITY – STRONG TIES FOR COMPLEXITY?

The main-argument of Granovetter (1973) is that distant and infrequent relationships, which represent weak-ties, are efficient for knowledge acquisition and sharing as they offer access to new knowledge by bridging otherwise disconnected individuals and spheres of knowledge within or across organizations. Similarly, Weick (1976) argues that organizational entities that are only loosely tied to other entities are more adaptive because they are less constrained by the organization system of which they are part. Put simply, they can raid around and tap into others' brainpower without getting tied up by formal requirements to assist various teams or units.

Hansen (1999) uses a network study to explore how weak inter-unit ties help a new product development team with purposeful knowledge-sharing. His findings are that while weak ties help the team find new knowledge located in other units, the weak ties are not useful in supporting the actual transfer of complex knowledge. The more complex the knowledge, the stronger the ties required to support its transfer. If these findings are correct, it would be reasonable to assume that weak ties will accelerate development speed when the required knowledge is not complex. Conversely, weak ties will not be supportive, or even slow down speed, in situations of high knowledge complexity. Research findings by Hite and Hesterly (2001), Uzzi (1996), Rowley et al. (2000) and Van Wijk et al. (2003) confirm that strong ties are positively related to firm performance when the environment demands a relatively high degree of exploitation, and that weak ties are beneficial for exploration purposes and to prevent the network's insulation from market imperatives.

A critical problem remaining unsolved by all authors reviewed in this last section is that of managing and steering the 'uncontrollable fuzzy front end' of innovation, as this depends mainly on weak ties. In this context, the arguments of structural holes and bridge ties, outlined below, offer new possibilities to take better control of networked innovation.

2.1.10 USING STRUCTURAL HOLES AND BRIDGE TIES TO TAKE CONTROL OF NETWORKED INNOVATION

Burt (1992, 65) describes the way in which '*social structure renders competition imperfect by creating entrepreneurial opportunities for certain players and not for others*'. He distinguishes between: financial, human and social capitals, and argues that social capital is as critical as financial and human capitals. Social capital is at once the structure of contacts in a network and resources they each hold, in particular *who* they can reach and *how* they can reach them. Easily accumulated contacts with alike people do not expand the network as much as they fatten it, weakening its efficiency and effectiveness by increasing contact redundancy and tying up time. Burt (1992, 72) holds that '*increasing the network size without considering diversity can cripple the network in significant ways*'. What matters is the number of nonredundant contacts, which lead to new people who bring new information benefits.

A network dense with redundant contacts is virtually worthless as a monitoring device because the strong relations between people in the network means that each person knows what the other people know, so they will discover the same opportunities at the same time. The dense network is inefficient in the sense that it returns less diverse information for the same cost as the sparse network. A solution is to put more time and energy into adding nonredundant contacts to the dense network. Nonredundant contacts are connected by a structural hole, which is a relationship of nonredundancy between two contacts. The hole is a buffer, like an insulator in an electric circuit. As a result of the hole between them, the two contacts provide network benefits that are synergetic rather than overlapping. Nonredundant contacts are disconnected in one of the following two ways: either directly in the sense that there is no direct contact, or *cohesion*, between the two persons, or indirectly in the sense that one person has contacts that exclude the other person's contacts. Conversely, two contacts are redundant to the extent that they are connected to each other by a strong relationship, which indicates the absence of a structural hole. In addition to cohesion, *structural equivalence* is another useful indicator for detecting structural holes. Two people are structurally equivalent to the extent that they have the same contacts. Regardless of the relation between structurally equivalent people, they lead to the same sources of information and are therefore redundant. While cohesion concerns direct connection, structural equivalence concerns indirect connection by mutual contact. For example, if three contacts have no direct ties with each other they are nonredundant by cohesion. However, if the social network of each contact leads to the same cluster of more distant players then the contacts are redundant by structural equivalence.

The optimized network has two design principles: *efficiency* and *effectiveness*. The efficiency principle says that you should maximize the number of nonredundant contacts in the network to maximize the yield in the structural holes. The effectiveness principle requires a shift in perspective. Burt (1992) distinguishes between primary and secondary contacts and recommends to focus resources on preserving the primary contacts. The shift in perspective is that contacts are not people on the other end of the contact's relations; they are instead ports of access to clusters of people. Instead of maintaining relations with all contacts, the task of maintaining the total network is delegated to primary contacts. Where efficiency concerns the average number of people reached with a primary contact, effectiveness concerns the total number of people reached with all primary contacts. Accordingly, efficiency concerns the yield per primary contact, while effectiveness concerns the yield of the network as a whole.

We typically tend to live in clusters of strong relationships, which allow information to circulate at a high velocity, but each member of the cluster tends to know what the other members know as well. Therefore, and this is the key proposition of Burt (1992, 82), *‘the spread of information on new ideas and opportunities must come through the weak ties that connect people in separate clusters’*. Weak ties are essential to the flow of information that integrates otherwise disconnected social clusters into a broader society.

Burt’s structural-hole argument complements the strength of weak ties argument of Granovetter (1973) in two interrelated ways. First, the causal agent in the phenomenon is not the weakness of tie itself, but the structural hole that it spans. Tie weakness is a correlate, but not a cause of access to nonredundant information. Second, by shifting attention away from the structural hole responsible for information benefits to the strength of the tie providing them, the weak-tie argument obscures the control benefits of structural holes. In other words, the structural-hole argument gives us new possibilities to manage and steer the previously uncontrollable information benefits in the fuzzy front end of innovation.

While Granovetter’s (1973) weak tie argument focuses on the strength of relationships that span the chasm between the two structural clusters, Burt’s (1992) structural hole argument is about the actual chasm spanned – not on the strength of the relationship that spans the gap. It is the chasm spanned that generates information benefits through its function as a bridge over a structural hole. Nonredundant (typically weak) ties are bridges to other clusters. The bridge strength is an aside in Burt’s (1992) structural hole argument, because information benefits are expected to travel over all bridges, strong or weak. His focus is more on how networking benefits vary between redundant and nonredundant ties, which are not always equal to strong and weak ties. The task of the strategic player is to build an efficient and effective network through excellent selection, development and nurturing of bridge ties. Full attention to relationship management is key to preserve the information benefits of bridges, or else they will ‘simply’ fall into their natural state of being weak ties.

The bridge tie of Spiderman to Mr. Grandissimo was very strong indeed and yet it closed a structural hole between Porsche and an external network that secured partly exploration and mainly exploitation (production) of ceramic materials for brakepads. Accordingly, we have reasons to believe that access to complementary nonredundant resources and skills also can be given through strong ties – and not only through weak ones.

2.1.11 SUMMARIZING COMPLEMENTARITIES OF STRONG AND WEAK TIES

Based on the arguments outlined above, it seems reasonable to assume that strong and weak ties are complementary from the perspective of time, and that the structure of an ideal network should maximize the yield per primary contact. We also learn that weak ties are likely to promote diversity and creativity in idea creation and accelerate development speed in early phases of exploration when the required knowledge is not complex. Conversely, weak ties may slow down speed in situations of high knowledge complexity where strong ties are required to support integration of results for exploitation of innovation – as opposed to further disintegration into new creative sub-problems. Accordingly, it seems that radical innovation requires management of both weak and strong ties cutting across both peripheral and core networks with a strong focus on developing and managing relationships for transfer and transformation of

information into innovation across multiple levels. Weak ties seem to be particularly useful in open creativity networks to enrich the creation and exploration of new knowledge. Wide know-who will be the main-driver in extensive networks of complementary (non-redundant) knowledge. Conversely, strong ties are more critical in rather closed process networks to drive the integration of innovation – from a creative concept into solid business plans, prototypes and commercial products. Strong know-how is the driver in a focused network of similar knowledge. Know-who will add complementary knowledge when required. As illustrated by Spiderman, this complementary knowledge can also be acquired by a strong bridge tie across a structural hole – and not always through weak ties. This book argues that successful spidermen are highly multicompetent acting in core teams of past strong ties and a multitude of current weak ties.

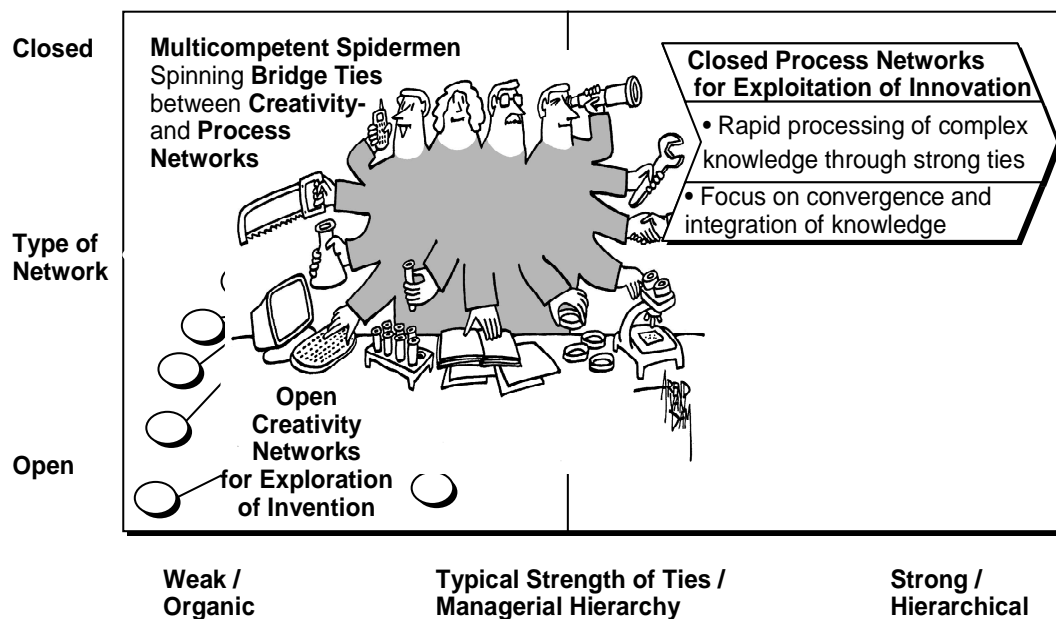


Figure 2 A Networked Perspective of Know-Who Based Entrepreneurship

Figure 2 summarizes the network perspective of know-who based entrepreneurship – still with multicompetent spidermen at the core, but with a clearer positioning of the complementary but structurally contrasting networks: open vs. closed, and (typically) weak vs. strong managed organically vs. hierarchically-. Our framework suggests that firms with relationships in open networks have greater latitude in their innovation strategies as they have more extensive and nonredundant opportunities for collaboration (Burt, 1992). Also, the more social capital available to a firm in terms of know-who and relationship-ability, the less resources it needs to manage existing relationships and the more resources it can use to establish new ones (Walker et al., 1997).

3. METHODOLOGY

Our approach is to build a deep understanding of how R&D processes evolve over time. Accordingly, we started the interview process back in 2007 and finalized our last interviews in January 2009.

The two cases also serve as our preferred basis for further investigation of the topic of this paper – based on the long-term relationships developed with the informants who share our interest in advancing the knowledge frontiers in this area.

Our research method is based on abduction (Alvesson and Skoldberg, 1994; Dubois and Gadde, 2002) combining elements from both the inductive approach and the deductive approach. Continuous matching of theories with reality and vice versa has been our approach to secure empirical support for the theoretical framework. The basis for this process is a holistic multiple case study (Yin, 2003) combined with the combination of theories outlined above.

The empirical data has been collected from the two case companies; Tetra Pak and Porsche. Within Tetra Pak the interviews covered the person in charge of the establishment of the R&D unit in China and the overall R&D transfer process. Furthermore several researchers with expatriate experience were interviewed in order to tap into their experience. All interviewees have been interviewed several times in order to enable tracking of the development of the investigated case over time. Within Tetra Pak, interviews were made both in Scandinavia and in China. In China, we interviewed employees in the foreign R&D center as well as the universities – so as to get a more complete picture. Complementary information in terms of secondary data has been collected, but the main parts of the empirical data have been primary data, which have been collected by the use of semi-structured interviews in person and by phone. Through the use of multiple sources for the case studies internal validity concern has been addressed for the case studies in terms of number of interviewees and their positions in the organizations. The purpose of presenting quotes from a large number of interviewees was to add verisimilitude and represent a wider network of the different actors across multiple levels in the cases.

The issue of construct validity and reliability has been addressed as key informants have reviewed the case reports – both the individual cases as well as a previous draft of this paper. External validity is enhanced by covering two quite different industries - and two different geographical contexts, which are Europe (Porsche) and the emerging economy China (Tetra Pak) enabling comparisons between different industries and geographical contexts. It is also enhanced by developing a relatively industry-independent theoretical framework using the abductive approach outlined in this section.

The aim is theoretical development, rather than testing of theories or common ‘grounded theory’ approaches with the objective to continuously assessing the empirical support of a theory, or, inversely, a reality’s theoretical support, through the matching of theories with realities (Strauss and Corbin, 1990). This research project has been a combination of in-depth empirical research and reflection in action (Schön, 1983).

4. CASE STUDIES: PORSCHE AND TETRA PAK

The empirical material presented here is based on a new product development project from Porsche and a new product development- and R&D transfer project from Tetra Pak.

4.1 *PORSCHE - GIVE ME A BRAKE*

Porsche and Mercedes-Benz were competing against time to bring out the first ceramic brake system into the market of commercial vehicles. In the late 1990s, the CEO of

Porsche was well aware of their know-how disadvantage: They had started their research efforts in this field much later than Mercedes-Benz, and had less than one tenth the number of researchers in-house. Still, the CEO ordered his relatively small engineering team to give him a ceramic brake system by 2002, which should be able to last 300 000 km and withstand temperatures above 1000 °C without being oxidized (conventional iron brake discs last 60 000 km and withstand temperatures at 700°C). So far, ceramic brakes had only been used in racing cars and aerospace applications. Ceramic brakes discs enable weight reduction and higher brake performance also at elevated temperatures. When the project was initiated F1 cars used carbon-carbon discs similar to ceramic brakes, which needed to be changed every 1000 kilometers and therefore it was not feasible to implement the existing brake in ordinary cars. The American F16 Fighters were using ceramic brake systems with much higher longevity than the F1 applications, but the very special Ceramics Silicon Carbide solution was top confidential and neither accessible to Porsche, nor to Mercedes-Benz.

4.2 SPINNING A NETWORK OF GLOBAL KNOW-HOW

The few material researchers of Porsche were not focused on internal exploratory research, but on global networking and technology intelligence to identify and bring together the most relevant external sources of know-how in this area. Spiderman – the experienced Head of Porsche Brake Systems Engineering – had developed state of the art brake systems for more than thirty years. He selected two academic research institutes and gave them one year each to explore and consolidate decades of research in the related areas and develop a specific compound based on ceramics and very special carbon fiber. He also had a research collaboration with Deutsches Zentrum für Luft- und Raumfahrt (DLR), which in the end resulted in a couple of strategic patents – now exclusively owned by Porsche. In addition, Porsche had five experienced manufacturing process-chain and quality management experts with great system understanding, who dedicated significant time to the project. Traditionally, Brembo in Italy was the partner of choice in Porsche's brake systems, but as Brembo also worked with important competitors including Mercedes-Benz, Porsche started to look for another development partner for this specific project. Spiderman identified a company that did not have any experience in automotive components, but had absolute world-class competence in carbon ceramics for aerospace and industrial applications. More important still, this company also had a strategic partnership with the American aerospace composite company that was the owner of the proprietary surface treatment technology used for the F16 fighters.

Spiderman now had spun a forceful network consisting of one specialized supplier for ceramic materials to produce the actual disc, and two suppliers to develop the calipers and other critical components required to assemble a complete brake system. The perhaps most challenging requirement for this new brake-disc amalgamation was to maintain the required structural properties at temperatures exceeding 1000 degrees centigrade – in addition to the longevity requirement of 300 000 kilometers of normal use. The first prototypes of the new ceramic discs worked only until temperatures of 650 degrees, after which some of the carbon material evaporated and the disc was oxidized. Further material exploration was called for so as to optimize the organization of the silicon carbide in the disc and reduce or prevent oxidation of its active surface. To solve this and related manufacturing problems further networking was required. Spiderman, who had already brought in a dozen academic researchers from the two

domestic institutes, now made a more extensive networking effort. Spiderman also made visits to the American aerospace composite company to learn about their surface treatment know-how, which he brought back to his own network of engineers in Germany.

Spiderman organized open seminars to present the status of Porsche's most strategic development project. Of course, competitors such as Mercedes sent their leading experts to these seminars. They asked questions and contributed to a dialogue that helped Spiderman make better progress in the project. Moreover, Spiderman spotted the best expert and acquired him into his own project network – by asking DLR to recruit the expert, who was then transferred into the ceramic brake development team.

Porsche funded the research made by the academic partners to secure exclusive patent-ownership of the unique geometry that was developed. Porsche also performed all quality control of the new components. This was made in the new center, which counted a total of thirty people of which less than ten were regular Porsche employees. The quality control was a particularly important aspect with respect to product liability issues. Here, Porsche's thirty years of experience in designing highly competitive brake systems added significant value to the collaborative network. As the new disc manufacturing partner did not have any prior know-how in automotive parts, Porsche had to invest several thousand man hours in knowledge transfer activities to add this critical know-how to their new supplier of the revolutionary ceramic disc.

Through the extensive networking and mobilization of leading know-how from several countries and continents, the project network of Porsche identified a revolutionary ceramic brake system solution. To achieve the goal, a technology to prevent the oxidation of the carbon fibre had to be developed. The extended network created the unique solution of applying a silicon carbide matrix to the carbon fibre, which generated a carbon ceramic(C/SiC). The resulting product featured both better durability and safety.

The new discs – commercially available since 2002 – offer higher performance during heavy workloads both in dry and wet environments. The actual weight reduction of 60 per cent, which is about 5 kg per wheel, has an enormous impact since it affects fully unsuspended weight. Ceramic composite brake discs also offer the advantage of zero corrosion and shorter braking distance.

Porsche holds the full patent for the geometry, but maintained only two years of exclusive rights to commercialize the system so as to capture both licensing revenues and better scale-economies in manufacturing. Two leading car manufacturers are already licensing the new technology from Porsche to apply it to their high-performance models. In this way, the networking strategy resulted both in brand enhancing patent protected innovation leadership and in additional revenues.

4.3 *TETRA PAK*

Tetra Pak already had a strong global footprint with China being the single largest market when it decided to establish a new R&D center in the emerging economy. Manufacturing capability had been established since early 2000 and the plan was to follow with R&D – mainly to reduce time to market for new higher-performance and lower-cost distribution equipment. There was an increasing need for low-cost distribution equipment in China, but this would require significant innovation to fulfill

the very challenging cost and performance targets. Transferring R&D to China was a bold move to take a fundamentally new approach to the whole innovation process. Rather than doing R&D at the home base R&D unit and then transfer the results to China for manufacturing, it was decided to establish a new R&D center dedicated to innovation excellence using a more open and networked university collaboration approach. The company arranged an innovation contest in distribution equipment between well-selected key universities. External consultants were engaged to support identification of the right researchers. Professors coached masters and PhD students to conduct joint brainstorming sessions in order to develop new concepts. **xx Sigvald please verify that the following two sentences are true:** One of the involved Chinese professors invited not only the participating team at his university to come up with ideas, but included also approximately 300 further students at the University to come up with good ideas to be used in the project. Tetra Pak applauded this initiative. New relationships between employees of Tetra Pak and local students were fostered during the brainstorming sessions and the consecutive coaching sessions. In order to update and develop the concepts further, additional information was given to the student teams during the review sessions of the early concept ideas. These sessions were organized such that all teams had access to the feedback given to each individual team thereby ensuring cross fertilization of ideas between the competing teams. During two different review sessions several concepts were reviewed in Europe as a result of the contest. The first session provided a neutral third party opinion from a dozen invited technology consultants. During the second session one concept was selected for further development by Tetra Pak's distribution equipment experts. The winning university was invited to temporarily join Tetra Pak's R&D center in Sweden to acquire advanced CAD training focused on further validation and early implementation of the concept. Also the coaching professor was joining this "human knowledge transfer" from China to Sweden. Further collaboration continues in China also with those universities that did not win the first innovation competition.

5. ANALYSIS

Knowing who has the know-how, defining new access points to this know-how and converting it into new value networks created a new breakthrough for Porsche. Knowing who has the know-how was made possible by deliberately spilling over- or sharing knowledge with external parties including employees working for competitors. The innovation contest between the universities enabled Tetra Pak to reach new avenues of thought in terms of the eager young minds at the universities without formally managing or employing more people. The consultants - university professors functioned as structural holes, which identified the talent pool to include in the project.

5.1.1 KNOCKOUT NETWORKING LESSONS

Let us start with some terminology: Porsche clearly recognizes a need to leverage external brainpower for exploration of innovation, i.e., for creative research and discovery. For this purpose, Spiderman establishes contacts to so-called creativity networks. The creativity network is mainly an open and loosely coupled arms-length network encompassing primarily weak ties to selected external scientists and experts. The purpose of the creativity network is to create new scientific knowledge that can be transformed into commercialized innovation by a project network.

The purpose of a project network is to manage the balancing act between exploration and exploitation so as to secure breakthrough innovation. Spiderman builds a project network that involves two academic centers of brainpower and a large number of leading experts who secure the initial knowledge creation required to define the ceramic material. However, defining a material is still far from pursuing a full innovation cycle. This is why a so-called process network was required to secure development and manufacturing of the ceramic material in the desired shape of a disc.

As a company, Porsche has innovated both the processes and business models for absorption of external technologies and skills and places very strong emphasis on social ties.

The relationship-dimension of the Porsche case suggests that a dominance of weak ties is beneficial for exploration in open creativity networks, and a dominance of strong ties is required for exploitation in more closed process networks. In network terms, the process network is therefore closed, tightly coupled, and hierarchical. The creativity network is the complete opposite with a relatively open structure. It contains both individual and organizational levels. As illustrated by the case, the creativity networks are mainly social networks, driven by personal relationships. Selected individuals at the universities are more important than the universities themselves. Accordingly, the social networks are dominating the organizational networks and act mainly as antecedents of organizational networks. The project network is a mix of creativity- and process networks, being semi-open at the beginning and more closed during the exploitation phase, when bridging the two opposing networks.

The mini case also illustrates how a typical breakthrough innovation evolution starts with a dominance of creativity networks to mobilize the required expertise to develop a revolutionary concept. The evolution continues by linking the exploration-oriented creativity networks to exploitation-oriented process networks to manage the conversion from knowledge creation to business implementation for breakthrough innovation to happen. The process network-dominance in the exploitation phase was witnessed by Porsche's integration of the best individuals from the creativity networks into the process network at Porsche's premises where most actors involved finally ended up.

5.2 COMPARISON OF PORSCHE AND TETRA PAK

Although the two case companies operate within different industries some similarities can be identified, since both companies are active on the business to business (B2B) market. Although Porsche can be characterised as a company, which is active within high-end consumer products, the main profit generator for Porsche is to provide R&D services and license out their technologies to other car manufacturers.

In the Porsche case deliberate and intended knowledge spillover enabled identification of strategically important external knowledge to be internalised and applied by the company.

Company	Goal of the innovation strategy
Porsche	<ul style="list-style-type: none"> Develop ceramic brakes for standard vehicles
Tetra Pak	<ul style="list-style-type: none"> Develop low-cost distribution equipment in China

Table 1. Innovation strategy goals of the case companies

Company	Core elements in the innovation strategy
Porsche	<ul style="list-style-type: none"> • Clearly defined desired result • University competitions • Intended knowledge spillover to: universities, invited experts of competitors, unexperienced suppliers with complementary skills • The R&D activities of the company are highly outsourced
Tetra Pak	<ul style="list-style-type: none"> • Less clearly defined desired result • University competitions • Intended knowledge spillover to universities • The R&D Activities of the company are in-house focused and the winning university was invited to join the R&D Headquarters in Lund for four months

Table 2. Core elements of innovation strategy of the case companies

Company	Experienced benefits of intended knowledge spillover
Porsche	<ul style="list-style-type: none"> • First to introduce ceramic brakes in the automotive industry • Brand Equity Increase - as a result of positive differentiation through innovation • Increased profits as a result of increased sales and licensing fees
Tetra Pak	<ul style="list-style-type: none"> • Time to market from concept to implementation • Total Innovation Project Cost relative to degree of Innovation • Impact in terms of anticipated increase in sales • Brand Equity Increase - as a result of positive differentiation through innovation in distribution equipment • Recruiting advantage through increased

	awareness among leading Chinese universities
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Table 3. Knowledge spillover benefits experienced by the case companies

Whereas Tetra Pak was in need of brainpower for the more general mechanics and mechatronics related task of developing distribution equipment, Porsche was in need of more specialized brainpower and in this sense what Porsche was looking for was more clearly defined.

6. DISCUSSION

Knowledge management approaches such as disintegrating knowledge creation processes mitigates the non-productive use of strategically important spillover knowledge. They can, however, not prevent the spillover of knowledge as such! Actually, preventing knowledge spillover might harm the company since it may decrease the development of strategically important external knowledge which it is possible for the company to tap into. Especially the ability to identify strategically important external knowledge may be hampered if knowledge spillover is restricted excessively.

Intended - and unintended knowledge spillover alike can have both positive and negative effects.

Only if the spillover knowledge is used in ways which are negative for the knowledge contributing company is knowledge spillover negative for the contributing company!

Positive R&D knowledge spillover can be defined as knowledge spillover, which either enables the improved use of knowledge assets already available for the company, and/or knowledge spillover which enables the use of relevant knowledge assets, which are not available for the company.

To share or not to share knowledge is not the question. The question is if knowledge sharing and knowledge spillover are managed or not. Does it happen as a result of an intended and deliberate process which enables the company to capitalise in new ways on the contributed knowledge, or does it happen in unintended ways which may or may not harm the company? If the company does not manage its spillover knowledge, instead knowledge spillover will manage the company!

We readily admit that intended - and unintended knowledge spillover alike, can cause negative knowledge spillover. The former may, however, be less likely than the latter and intended knowledge spillover can facilitate new benefits, which makes it worth it to run the related risks!

Through symbiotic networking and relationship management, new shortcuts to bridge the gap between exploration and exploitation can be found so as to accelerate the process from knowledge creation to business-implementation.

7. CONCLUSIONS - CONTRIBUTION TO INNOVATION THEORY AND/OR PRACTICE

The recommendation should be to change from an excessive focus on the negative side of knowledge spillover and instead to consider the knowledge creation and innovation

potential related to mutual sharing and creation of knowledge between the company and its surrounding environment.

By proactively facilitating knowledge sharing with relevant parts of the surrounding environment, the company enables itself to feed knowledge into its surrounding environment - thereby developing the innovation potential of the environment for exploration purposes, and the opportunities to identify and to feed knowledge back to the company for exploitation purposes, from the same environment.

The resulting theoretical framework, built on the existing networking - and knowledge creation theories, is useful for the further analysis of positive R&D knowledge spillover effects.

8. LIMITATION AND FURTHER RESEARCH

The Porsche case gave an example of how innovation partners can be used to recruit R&D employees from competitors in an indirect way without infringing competition clauses which may exist and which makes it illegal for employees to immediately start working for competitors. Open innovation as a way to work around competition clauses prohibiting employees to immediately start working for competitors when they quit a job is an area which might need further research.

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NOTES

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- ⁱ Effective in the sense that any networking activities are explicitly targeted towards the type of knowledge needed for business purposes, e.g., a specific project, or a special skill needed for a process.
- ⁱⁱ Efficient in the sense that the cost and efforts of their networking activities to

acquire, transform and apply knowledge are comparably low, thanks partly to their know-who, which supports rapid identification of both those who have the knowledge as well as of those who need it, and partly to their multicompetent skills, which support rapid acquisition and transformation of both tacit and explicit knowledge.